FSF3847 Convex optimization with engineering applications
Spring 2023
Instructors: Mats Bengtsson, Anders Forsgren and Joakim Jaldén

General rules for homework assignments

- Each student has to hand in individual solutions.
- You are encouraged to use suitable computer programs, such as Matlab, for computations and drawing pictures.
- You may cooperate. Discussions are encouraged. If you receive help from someone, say so in your solutions.
- You must hand in your own original solutions. You are *not* allowed to make use of solutions made by others in any form.
- Late assignments are not accepted. Please observe the due dates.
- For each assignment, hand in solutions as one pdf file via Canvas (`https://canvas.kth.se/courses/42086/assignments`). You may either write by hand or typeset by using for example LaTeX.

Good luck!

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Homework Assignment 1
Due Tuesday April 4 2023

Exercise 1.1. Solve Exercise 2.7 in *Convex Optimization*, p. 60.

Exercise 1.2. Solve Exercise 2.9 a) in *Convex Optimization*, p. 61.

Exercise 1.3. Solve Exercise 2.15 a), b), d) and e) in *Convex Optimization*, p. 62.

Exercise 1.4. Solve Exercise 3.13 in *Convex Optimization*, p. 115.

Exercise 1.5. Solve Exercise 3.24 a)-f) in *Convex Optimization*, p. 117. You need only consider convexity and concavity, not quasiconvexity and quasiconcavity.

Exercise 1.6. Solve Exercise 3.27 in *Convex Optimization*, p. 118.

Exercise 1.7.

a) A symmetric $n \times n$ matrix H is said to be positive semidefinite if $v^T H v \geq 0$ for all $v \in I\!R^n$. Show that the set of symmetric positive semidefinite matrices is a convex set. Can you give an efficient way to determine if a symmetric matrix is positive semidefinite?

   Hint: Exercise 1.6 may contain helpful information.

b) A symmetric $n \times n$ matrix H is said to be copositive if $v^T H v \geq 0$ for all $v \in I\!R^n$, $v \geq 0$. Show that the set of symmetric copositive matrices is a convex set. Can you give an efficient way to determine if a symmetric matrix is copositive?

   Hint: It may be helpful to find information on the computational complexity of detecting copositivity.

c) If your answer is not yes in both instances, which of the two sets of constraints on H would you be prepared to consider in an optimization problem, where your aim is to design a method which is guaranteed to find a global minimizer?

Comment: Interpret *"efficient"* in a way you find suitable.

Good luck!